COSIA | CANADA'S OIL SANDS INNOVATION ALLIANCE

Guide for In Situ Reclamation in the Oil Sands Region of Alberta

Reclaiming Aggregate and Borrow Excavations Associated with EPEA Approvals to Water Bodies

April 30, 2017

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Acknowledgements

Sincere thanks are given to all individuals who have participated in the production of this report. A total of 45 pages of comments were received from 7 COSIA members and third-party reviewers. Third party reviewers included Susan McGillivray (Alberta Environment and Parks), Margaret Magai (Alberta Energy Regulator), and Amanda Schoonmaker and Bin Xu (NAIT Boreal Research Institute). We particularly appreciate the time afforded to us by the staff at CENOVUS, who met with the editorial team on 2 separate occasions to share their knowledge and experience on designing and constructing gravel and borrow pit water bodies. We also thank the NAIT Boreal Research institute for meeting with us and sharing their insights on wetland reclamation. We particularly appreciate the leadership provided by Judy Smith (Shell) and Jeremy Reid, who co-chaired the COSIA – EPA Led Study Steering Committee, and Jack O'Neill (COSIA) who ensured that everything ran smoothly.

Terms and Acronyms Used

AEP: Alberta Environment and Parks

AER: Alberta Energy Regulator

C&R Plan: Conservation and Reclamation Plan

CRBP: Conservation and Reclamation Business Plan

CWM: Course Woody Material - Material containing logs and broken-up logs, smaller pieces of debris such as roots, twigs, and branches that are not considered merchantable and have been salvaged following tree clearing.

Direct Placement - Areas in which mineral or organic topsoil has been directly placed (not placed from stockpile) to act as a propagule source for revegetation as well as a (soil) reclamation material. (AER(b), 2016)

EPEA: Environmental Protection and Enhancement Act

Equivalent Land Capability: The ability of the land to support various land uses after conservation and reclamation is similar to the ability that existed prior to an activity being conducted on the land, but that the individual land uses will not necessarily be identical after reclamation (Alberta Queen's Printer, 2016)

Land Capability: The ability of land to support a given land use, based on an evaluation of the physical, chemical and biological characteristics of the land, including topography, drainage, hydrology, soils and vegetation (Alberta Queen's Printer, 2016)

Marsh Plant Zone: The wet meadow and emergent zones of a water body. Water depth is <1m within this zone (Bayley et al., 2014)

PLCRCP: Project-Level Conservation, Reclamation, and Closure Plan

QWSP: Registered Qualified Wetland Science Practitioner

Ready for Reclamation: Areas that are no longer required for project activities and that are available for reclamation but where reclamation activities have not yet begun (AER(b), 2016)

Recontouring - Any activity related to the movement of soil parent material during land reclamation for the purpose of creating a landscaped surface that will blend into the surrounding landscape. This may include some areas where subsoil has been placed (AER(b), 2016).

Riparian Zone: The interface zone which between the upland and the marsh plant zone, strongly influenced by the presence of water (Bayley et al., 2014)

Shallow Open Water Zone: The deepest area of a marsh but <2m deep generally supporting floating and/or submersed aquatic vegetation (Bayley et al., 2014)

Shoreline development index (SDI): Ratio of water body shoreline length to shoreline length of circle of same area as the water body

Soil Suitability Criteria (Agriculture, Food, and Rural Development, 2004)

- Good (G) - None to slight soil limitations that affect use as a plant growth medium.
- Fair (F) - Moderate soil limitations that affect use but which can be overcome by proper planning and good management.
- Poor (P) - Severe soil limitations that make use questionable. This does not mean the soil cannot be used, but rather careful planning and very good management are required.
- Unsuitable (U) - Chemical or physical properties of the soil are so severe reclamation would not be economically feasible or in some cases impossible.

Specified Land: Land that is being or has been used or held for or in connection with […] the construction, operation or reclamation of a mine, pit, borrow excavation, quarry or peat operation […] but does not include that portion of a pit on which a waste management facility is operating or has been operated in accordance with a valid approval or registration under the Act and the regulations (Alberta Queen's Printer, 2016).

Year (Yr) – The calendar year, unless otherwise specified.

Foreword

The Guide for Reclaiming Aggregate and Borrow Excavations to Water Bodies is a presentation of current knowledge, recent research, and best practices employed in the Oil Sands Region of Alberta (OSR) and abroad. We hope that this guide can be used as a starting point in future reclamation projects. As more projects are completed, new knowledge should be incorporated into future editions of this document.

Aggregate and borrow excavations can range considerably in depth. We specifically wrote this document to reflect this fact – the document can be applied to water bodies ranging from shallow, non-permanent wetlands to small ponds and lakes. In all of these systems, the vegetated zone (defined as the area of the water body that has less than 2m of water depth) is most critical from and ecological and biodiversity perspective. Correspondingly, this document focusses on the design of this zone, irrespective of water body depth. As you will see in this guide, the characteristics of the vegetated zone (width, plant diversity) are primarily driven by slope. Slopes in natural lakes (CEMA, 2012a) and wetlands (CEMA, 2014) on the Boreal Plain are highly similar, which is not surprising since the Alberta landscape was created by common geological processes.

1.0 Introduction & Background

1.1 Introduction

The Guide for Reclaiming Aggregate and Borrow Excavations to Water Bodies (The Guide) was prepared for Canada's Oil Sands Innovation Alliance (COSIA) to provide broad guidance for reclamation on In Situ facilities, specifically reclamation of water bodies in aggregate and borrow pits. The intended audiences for The Guide are those who are involved in reclamation planning, design, and operations. The Guide is designed to be used as a workbook - walking through the milestones and steps involved with planning for, designing, and constructing a water body from a borrow or aggregate excavation. It can also be used as a reference for In Situ company managers, regulators, stakeholders and consultants.

The objectives of The Guide are as follows:

1. Support the preparation of detailed reclamation plans.
2. Provide practical operational guidance for water body reclamation activities.
3. Provide a framework and structure that enables effective documentation of a water body reclamation project from start to finish.
4. Provide guidance towards attaining healthy aquatic ecosystems, self-sustaining water bodies, and land function and operability that are a close approximation of natural regional conditions.
5. Support successful reclamation certification.

This Guide provides general recommendations for water body reclamation. However, due to the wide range of potential site conditions and unique circumstances surrounding each reclamation project, **this Guide should not be considered to provide prescriptive direction to be applied across all applicable sites.**

1.2 Regulatory Background

Regulations, Approvals, and Commitments

Where an Environmental Protection and Enhancement Act (EPEA) Approval has been issued for oil production sites, operators are to utilize Specified Enactment Direction 001 (Government of Alberta, 1993) to guide preparation of applicable planning documents such as pre-disturbance assessments (PDA) and project- level conservation, reclamation, and closure plans (PLCRCP). When an area is ready for reclamation (from SED 001), the closure plan previously submitted (PLCRCP or CRBP) should be reviewed and discussions should occur with the appropriate regulator to discuss the development of a detailed (site-specific) reclamation plan. The site-specific reclamation plan should be aligned with the PLCRCP.

***The Guide* assumes that the EPEA Approval, regulatory conditions listed for the lease agreement, or any other provincial/local commitments made are followed.**

The Alberta Water Act (Government of Alberta, 2000) dictates that regulatory Approval is needed where activities affect a water body, which is defined as “any location where water flows or is present, whether or not the flow or the presence of water is continuous, intermittent or occurs only during a flood, and includes but is not limited to wetlands and aquifers”. Thus, with respect to aggregate and borrow excavations, a Water Act Approval and/or Licence may be required prior to development if excavating into the water table or for approval of the reclamation design is there is water impoundment (see Table 1; Alberta Environment and Parks, 2015).

The Alberta Wetland Policy (Government of Alberta, 2013), which is enabled by the Water Act and Public Lands Act, was developed to minimize the loss of wetlands; to conserve, restore, protect and manage Alberta’s wetlands in order to sustain the benefits they provide to the environment, society and economy. It was implemented for the Green Zone of Alberta on July 4th, 2016, and applies to all new activities that directly or indirectly affect wetlands after this date. The Policy does not apply retroactively to Water Act Approvals issued prior to the policy implementation. All users of *The Guide* should be familiar with The Alberta Wetland Policy and consult the appropriate regulator to understand how the Policy may apply to individual water body reclamation projects.

Under the Forests Act (Alberta Queen's Printer, 2000) and Timber Management Regulation (Alberta Queen's Printer, 1973), reclamation planners must follow the Alberta Forest Genetic Resource Management and Conservation Standards (Alberta Agriculture and Forestry, 2016) if they decide to collect native seeds or plants for reclamation purposes. Under the regulation, operators who want to collect seeds or plants will need to apply for Temporary Field Authorization (TFA).

The Guide assumes necessary regulatory Approvals have been obtained prior to commencing water body reclamation activities. Consultation with regulators is critical to ensure compliance with regulations and identify expectations for the project.

Table 1: Legislation that may apply to water body reclamation.

Legislation	Jurisdiction	Description
Fisheries Act	Federal	The federal fisheries act protects fish and fish habitat under Section 35, which is administered by the Department of Fisheries and Oceans (DFO).
Migratory Birds Convention Act	Federal	Provides best management practices to preserve and protect habitat necessary for the conservation of migratory birds, including their nest within Canada. Timing restrictions for vegetation clearing are in place based on general nesting periods of migratory birds in Canada.
Species at Risk Act	Federal	SARA helps to prevent Canadian indigenous species from becoming extirpated or extinct. It also aids in the recovery of threatened and endangered species through species lists. Activities may be restricted if Species at Risk inhabit or breed in the project area.

Legislation	Jurisdiction	Description
Forest Act / Timber Management Regulation	Provincial	Reclamation planners must follow the Alberta Forest Genetic Resource Management and Conservation Standards (Alberta Agriculture and Forestry, 2016) if they decide to collect native seeds or plants for reclamation purposes. Under the regulation, operators who want to collect seeds or plants will need to apply for Temporary Field Authorization (TFA).
Water Act	Provincial	A Water Act Approval is required where activities alter or may alter flow, level, or location of water by collecting runoff or groundwater. A Water Act Licence is required for impoundment, consumption, taking, or removal of water by collecting runoff, groundwater, or precipitation Information required with the Application includes: • Geology & Hydrology of the Area • End Land-Use Plan (Water Balance, Site Plans) • Groundwater Flow & Depth • Delineated Catchment • Water balance
Weed Control Act	Provincial	Weeds refer to plants identified in *Part 2, Section 8* of the *Weed Control Regulation.* The holder of this area is legally responsible to control noxious weeds and destroy prohibited noxious weeds within the project area.
Wetland Policy	Provincial	As per the Water Act (see above), the Wetland Policy requires Approval for activities that directly or indirectly affect wetlands. Wetland replacement is required when wetland impacts that cannot be avoided or minimized will result in permanent loss of wetland area. The Wetland Policy typically applies for new activities planned after the Policy came into force in the Green Zone on July 4th, 2016. As per the *Wetland Mitigation Directive*, wetlands constructed in advance of- or soon after- permanent wetland losses have been incurred may be used to fulfill replacement obligations (permittee-responsible replacement).
Wildlife Act and Wildlife Regulations	Provincial	The *Wildlife Act* prohibits the disturbance of wildlife habitation (wildlife house, nest, den, or beaver dam). Wildlife types and classifications, regions, and timings are identified within the *Wildlife Regulations*.

THE IMPORTANCE OF DOCUMENTATION

Documentation of reclamation activities is a regulatory requirement for a Reclamation Certificate application, thus, it is imperative to document project activities as they occur.

Through the use of forms, checklists, and decision flow-charts, this document has been built to assist the user with project documentation.

1.3 How to Use the Guide

This document is intended to be used as a workbook to develop and implement the site reclamation plan. The reclamation task list form in Appendix 1 is meant to assist in tracking progress towards achieving water body reclamation tasks and milestones. The front end of The Guide (Milestone 1) will be most useful in reclamation planning. Subsequent sections (Milestone 2-4) will guide construction, revegetation and monitoring.

The following symbology has been used in the document to assist the reader in sifting through the material.

- ▽ Critical project consideration. Failure to consider the topic may significantly affect the outcomes of the project.
- ! Particular attention is required to this topic to ensure successful outcomes.
- ✓ Good practice that should be followed.
- • Important factual information.

Assumptions made in the production of this document include:

1. Soil salvage and storage best practices have been conducted.
2. Any contamination issues have been addressed.
3. The vegetation acquisition processes addressed in this document assume the reclamation plans have accounted for the timing involved regarding seed collection and appropriate permits, seedling propagation, and/or nursery procurement.
4. Suitable conditions for water body development (which may not be the case for all sites) have been accounted for appropriate to revegetation techniques selected.
5. Upland reclamation has been addressed. This document does not specifically address upland reclamation.
6. Most importantly: **The Guide does not supersede EPEA conditions, conceptual reclamation plans (CRBP, C&R, and/or PLCRCP) or any other permits, dispositions, or commitments.**

1.4 Reclamation Goals & Objectives

The guidance provided in this document is based on creating water bodies on mineral soil. By definition, if the water body is less than 2m at its deepest point, it is a wetland. If it is deeper than this, it is a pond or lake. There are three major classes of mineral wetlands according to the Alberta Wetland Classification System (AWCS): swamps, marshes, and shallow open water wetlands. Marshes and shallow open water wetlands are located in depressions, whereas swamps tend to be associated with transition zones subject to frequent flooding. With respect to marshes and shallow open water wetlands, different forms exist, ranging from seasonal marshes (presence of water above the surface for 4-6 weeks) to semi-permanent marshes (water in them year-round, in the majority of years) and permanent shallow open water wetlands (water in them year-round) (AESRD, 2015).

Since The Guide addresses the design and construction of water bodies formed from pits, we focus on water body forms that are associated with depressions, i.e., lakes, ponds, marshes, and shallow open water wetlands. The reclamation goal associated with The Guide is to create depressional water bodies that have the hydrological and vegetation characteristics typical of these types of systems in northern Alberta.

2.0 Guidance

Planning for water body reclamation of *in situ* facilities in the OSR under an EPEA Approval begins when it is written in the conceptual plans, such as the CRBP, the C&R Plan and/or the PLCRCP. Detailed reclamation planning begins once a project area has been approved by Operations for final reclamation and land is ready for reclamation[1]. The following reclamation milestones structure the water body reclamation project. Detailed reclamation planning begins with Milestone 1.

Milestone 1: Creation of Detailed Water Body Reclamation Plan – Hydrology and materials balance are confirmed through surveys. Based on this information, soil prescriptions and final design have been developed. Revegetation approach is selected. Reclamation drawings are produced.

Milestone 2: Landform Construction & Soil Placement – Grading and contouring is conducted, using onsite reclamation material, to achieve the topography and slope as determined in Milestone 1. Soils are placed as per Milestone 1.

Milestone 3: Vegetation Establishment – The revegetation plan is initiated as per Milestone 1.

Milestone 4: Monitoring – Survey the site to determine vegetation establishment and any issues that may arise.

[1] note that reclamation can occur in one phase of pit development while resource extraction is occurring in another phase

This document presents tasks which fall under each of these reclamation milestones. The form in Appendix 1 can be used to track and document water body reclamation progress through the milestones to assist with project documentation.

Reclamation Milestone 1: Creation of Detailed Reclamation Plan

This chapter includes the steps and tasks leading up to, and including, creation of the final water body design. In support of reaching "equivalent land capability", the reclamation plan must address the physical, chemical, and biological characteristics of the land, including (Government of Alberta, 1993):

1. topography,
2. drainage,
3. hydrology,
4. soils, and
5. vegetation.

This Milestone addresses all of these components.

Milestone 1

Step 1.1 Initial Design	Information gathering Insert plant zones Wetland slope contours Wetland shape Determine elevation of water table Water level control
Step 1.2 Design Assessment	Materials balance Hydrology Geotechnical
Step 1.3 Final Design	Final wetland drawings
Step 1.4 Soil Prescription Plan	Determine plant zone area and final placement depths
Step 1.5 Revegetation Plan	Plant species selection Determine plant collection and establishment methods Scheduling revegetation
Step 1.6 Site Preparation	Water management
Step 1.7 Reclamation Construction Package	Final reclamation drawings Construction package

Step 1.1 Initial Design

Purpose: Create preliminary design topography (structural design) as a basis for calculating reclamation material and vegetation placement needs.

Guidance:

1.1.1 Information Gathering

The more information available at the front end of the design process, the better the design. To make informed decisions regarding the preliminary design, the following basic pieces of information are recommended:

- Refer to conceptual planning documents (e.g., C&R Plan, CRBP) to align conceptual design and detailed design.

- Obtain pit contours. It is important to work with existing pit contours as a starting point for the water body design contours. This will help avoid waste in reclamation material, which is a valuable resource. This may also include collecting bathymetric (water body basin topography) data from the pit using sonar on boats.
- Obtain surrounding topographical data (LIDAR or better) and map of surrounding ecosites. This will be used later to integrate the detailed design to the surrounding topography and vegetation types.
- Obtain any hydrogeological information. Borehole data will always provide geological and often can provide water table elevation data. Soils and vegetation site assessments may provide water table elevation data, especially if soil pits were dug. Adjacent water courses, and water bodies will provide an indication of the location of the water table.

1.1.2 Plant Zones

Vegetation communities self-organize into assemblages according to their tolerance to moisture, and thus reflect a gradient extending from the center of the basin outward. Submersed and/or floating aquatic plants typically occupy the **Shallow Open Water Zone**, which is typically from 1m to 2m in water depth. Rushes, cattails, and other robust sedges and grasses are tolerant of flooding up to 1 m deep and typically occupy the area of a water body called the **Emergent Plant Zone**. Sedges, grasses, and forbs that prefer water-altered soils and are tolerant of intermittent flooding occupy the outer perimeter of water bodies. This zone is called the **Wet Meadow Zone**. See Figure 1 for a conceptual representation of these plant zones.

The suitable representation of vegetation zonation is the most important structural component of water body design. A diversity of healthy plant zones is critical to provide the habitat requirements for a variety of wildlife groups (see Appendix 2). If one or more of the three plant zones is completely absent from the site, wildlife dependent on the missing plant zone cannot exist. Thus, ideally the water body design should accommodate all three zones. Since the Emergent Plant Zone and Wet Meadow Zones have identical sloping requirements, we have combined these zones into a common "**Marsh Plant Zone**" to simplify design drawings.

Guidance for the preliminary design of plant zones is as follows.

Shallow Open Water Zone:

- Water Elevation - Shallow Open Water Zone is located between 1m and 2m of water depth (under normal water level).

Marsh Plant Zone (incl. wet meadow and emergent plant zones):

- Water Elevation - The Marsh Plant Zone is typically located between -0.1m and 1m of water depth (under normal water level).

- ✓ Maximize the width (and thus area) of the Marsh Plant Zone (see Section 1.1.3 on how to do this). This has numerous benefits, including:

  - It is an effective way to increase plant and wildlife biodiversity.
  - The emergent plants in the marsh plant zone filter contaminants (e.g., sediments) from uplands prior to reaching the open water zone.
  - Roots stabilize soils and vegetation physically reduces wave energy. Thus plants, which are highly concentrated in the Marsh Plant Zone, are very effective at reducing erosion. This is significant since erosion is one of the most common issues in water body construction projects. An excellent erosion prevention measure can be to maximize the width of the Marsh Plant Zone.

- As a guide, the Marsh Plant Zone in Boreal Plain marsh wetlands covers approximately 2/3 of the total wetland area (Bayley, Wilson, Rooney, & Bolding, 2014). In other words, by area, the Marsh Plant Zone is proportionally the predominant wetland zone. As the water body is larger, the Marsh Plant Zone is smaller in proportion to the total water body surface area. In lakes, the Marsh Plant Zone + Shallow Open Water Zone (i.e., the littoral zone) covers between 10% and 40% of the total lake area (CEMA, 2012a). Although this may not be achievable everywhere in a water body reclamation design, due to limitations in reclamation material volumes, available area, or excavated topography, efforts should be made to maximize areas for establishment of Marsh Plant Zones.

Upslope from the Water Body:

- ✓ To allow important ecological functions to occur, water bodies should be bordered by natural vegetation within at least 250m of the water body edge (riparian + upland zone) (CEMA, 2014). The development of riparian zones bordering water bodies may provide protection from early sediment loading and periods of large moisture surplus as well as nesting and foraging sites (CEMA, 2014). Guidance for the initial design of adjacent lands is as follows.

Riparian Zone:

- The riparian zone is the interface between the upland and the water body. This zone is influenced by water and may be periodically flooded. Thus, plant communities in this zone are characterized by herbs, trees and shrubs that thrive in proximity to water.
- ✓ Water Elevation – The Riparian Zone is located above the normal water level. For design purposes, a freeboard of 0.5m above the estimated normal water level can be planned to accommodate water fluctuations into the Riparian Zone.
- ✓ Follow guidance such as *Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region (2010*), *Riparian Classification and Reclamation Guide – Revised Edition (2012),* or EPEA-related documents.

Upland Zone:

✓ Follow guidance for upland areas in the Oil Sands Region (e.g. *Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region, 2010*) or EPEA-related documents.

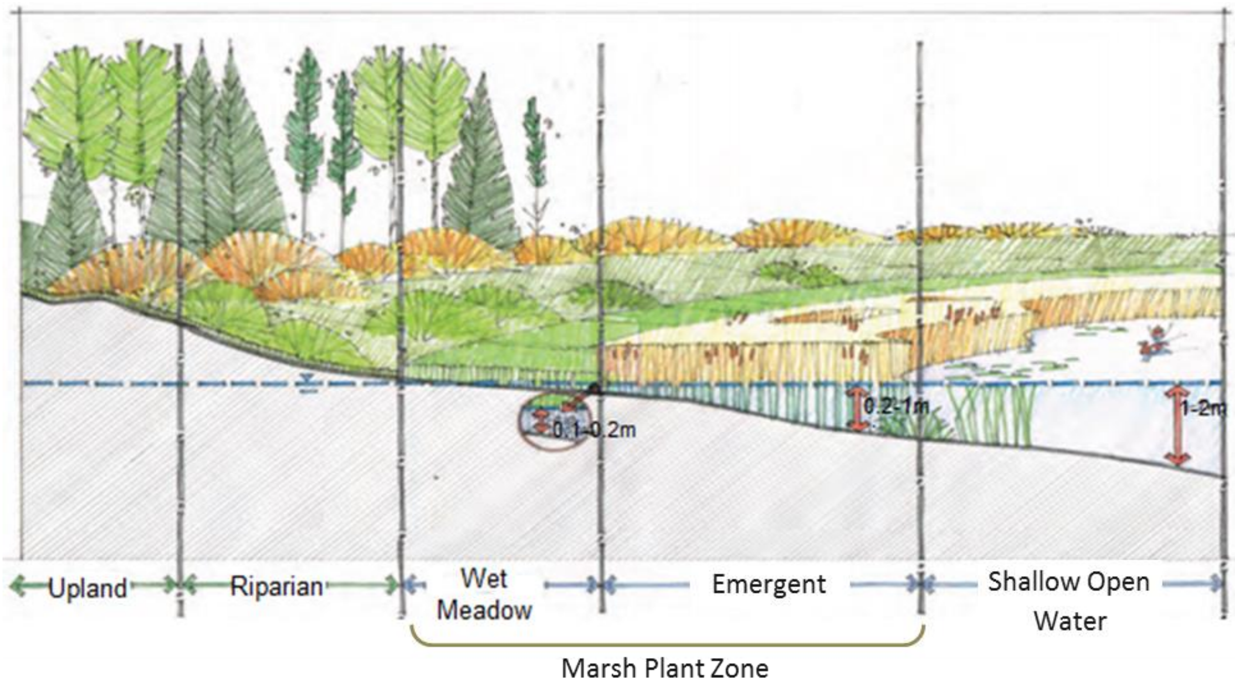

Figure 1: Plant zones in a natural water body (CEMA, 2014). Plant species represented in the image are for illustrative purposes only.

1.1.3 Water Body Slope Contours

! The width of the Marsh Plant Zone is a critical design component (see Section 1.1.2). Targeting gentle slopes will optimize the width/area of the Marsh Plant Zone (Figure 2). Recommendations for reclaimed slopes are presented in Figure 3 and Table 2. To add diversity of habitats, a variety of slopes around the perimeter can be used within the design.

✓ As a guide, natural slopes on the Boreal Plain are a maximum of 20H:1V (Forrest, 2010; Bayley et. al, 2014, CEMA, 2014, CEMA, 2012a). Although this may not be achievable everywhere in a water body reclamation design, efforts should be made to maximize areas with gentle slopes for establishment of healthy Marsh Plant Zones. We recommend a maximum Marsh Plant Zone slope, based on the following information:

- Basins with 7H:1V slopes or steeper will have narrow vegetation zones and can also have an absence of wet meadow zone (Forrest, 2010). Thus, in such cases, bird and other wildlife species that require wet meadow may not be supported.
- Basins with 10H:1V slopes or flatter typically contain all plant zones. Although plant species richness may be affected as compared to natural slopes of 20H:1V, 10H:1V slopes seem to provide sufficient emergent zone to support waterbird species richness comparable to natural water bodies (Forrest, 2010).

- Slopes flatter than 15H:1V aid flood attenuation (CEMA, 2014).

✓ Ensure design contours are integrated with the surrounding natural topography by connecting design contours with local surrounding area topography contours.

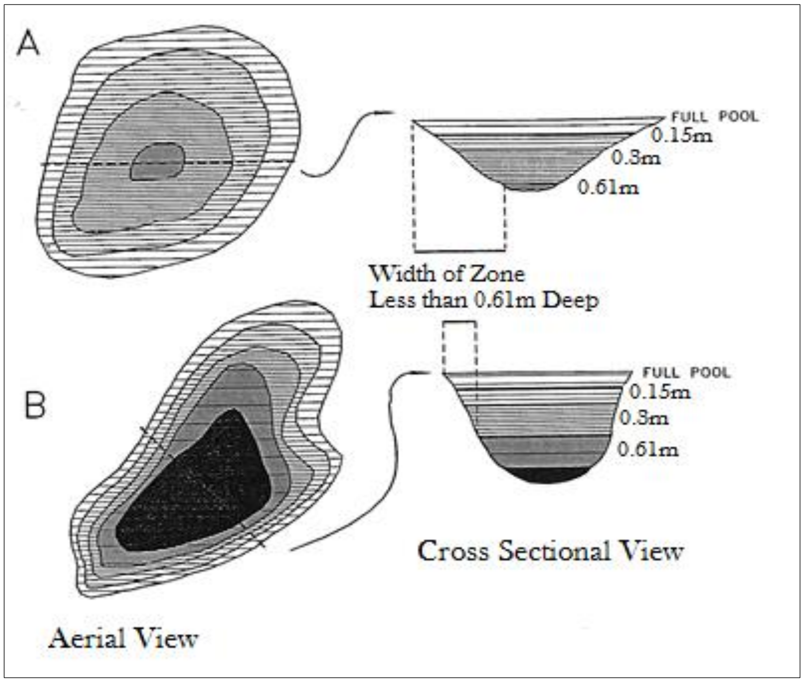

Figure 2: Importance of slope in water body development (adapted from Galatowitsch & Van der Valk, 1998). Gradual-sided depressions (A) will usually have a wide Marsh Plant Zone (MPZ) whereas steep-sided depressions (B) will often have a narrow MPZ.

Table 2: Recommended slopes for water body reclamation. ***See Figure 1 for visual depiction of zones.***

Zone	Recommended Reclaimed Slope	Notes
Deep Open Water zone (if present)	Slope from 2m below NWL to pit floor = 3H:1V	May be constructed to (5H:1V) slopes in some sections depending on reclamation materials.
Marsh Plant Zone + Shallow Open Water Zone (if present)	Maximum slope of 10H:1V; 2m below and 0.5m above NWL	Basins with 7H:1V slopes or more will have narrow vegetation zones and a lack of Wet Meadow Zone (Forrest, 2010). If reclamation material is lacking, focus gentle slopes on the Marsh Plant Zone (<1m of water depth). If reclamation material is more abundant, gentler slopes (20H:1V) may be added in some sections (CEMA, 2014).
Riparian Zone	Maximum slope of 7H:1V; begins at 0.5m above NWL	Riparian Zone may have a maximum slope of 7H:1V to encourage wildlife use and soil stability, and prevent erosion (Ross & Gabruch, 2015) (Alberta Environment, 2010).
Uplands	Variable	No greater than 3H:1V slopes on uplands. Create a rough and loose soil environment to create micro-diversity. Graded areas should be left scarified as an erosion control measure.

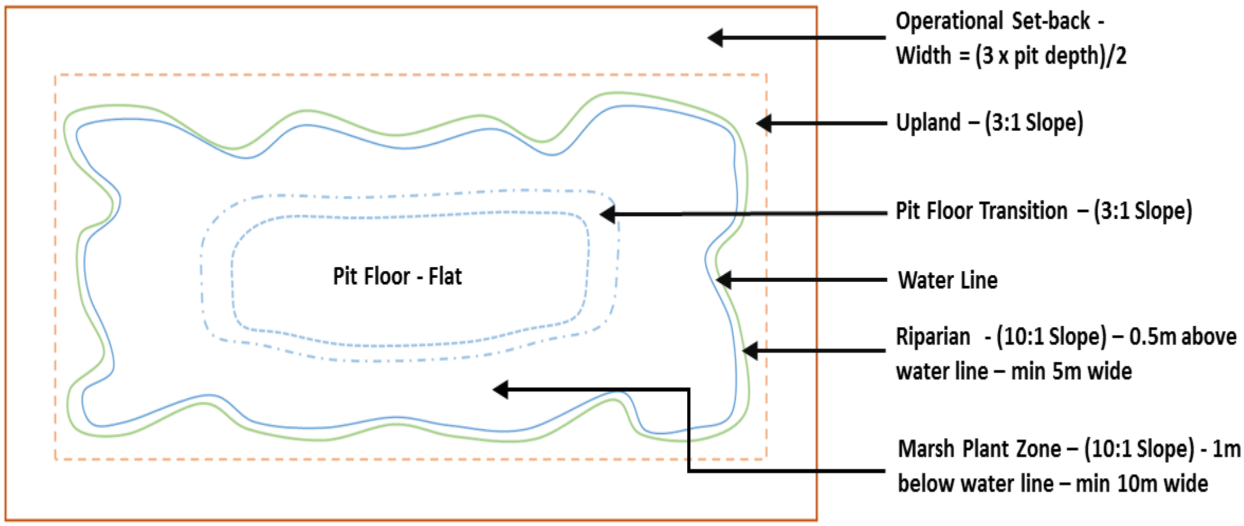

Figure 3: Example of conceptual water body zonation, associated slopes, and morphology. Note: This example is for a 2m deep wetland. In this case, the planner decided to end the 10:1 slope at the edge of the Marsh Plant Zone, rather than continue this slope deeper in the wetland, due to lack of material. Operational Set-back: In some cases, a set-back is put in place to allow placement of soil stockpiles. The material within the set-back can also be used as fill material pushed into the pit to achieve desired side-slopes.

1.1.4 Water Body Shape

- ✓ Variable shoreline with many bays and peninsulas (for example, see Figure 3) provides structural habitat diversity and will help minimize shore erosion. The Shoreline Development Index (SDI; Aronow, 1982) is calculated as the ratio of the length of the shoreline to the circumference of a circle of area equal to that of the waterbody. Aim for a SDI > 1.2, which represents complex shorelines with larger perimeter:area ratios.
    - The Shoreline Development Index is calculated as: $SDI = \frac{L}{2\sqrt{\pi A}}$, where L is the measured shoreline and A is the water body area.
- ✓ If available, excess fill can be used to build nesting and loafing island habitats for ducks and geese. Island habitats must have low accessibility from the shore to be effective. In general, island habitats should have a minimum diameter of 7m, be located at least 16m from shore, and be surrounded by water at least 0.75m (Galatowitsch & Van der Valk, 1998) (Zenner, LaGrange, & Hancock, 1992).
- ✓ In addition, local irregularities in the contour of the water body bottom will increase habitat heterogeneity (CEMA, 2014) (for example, see Figure 4).

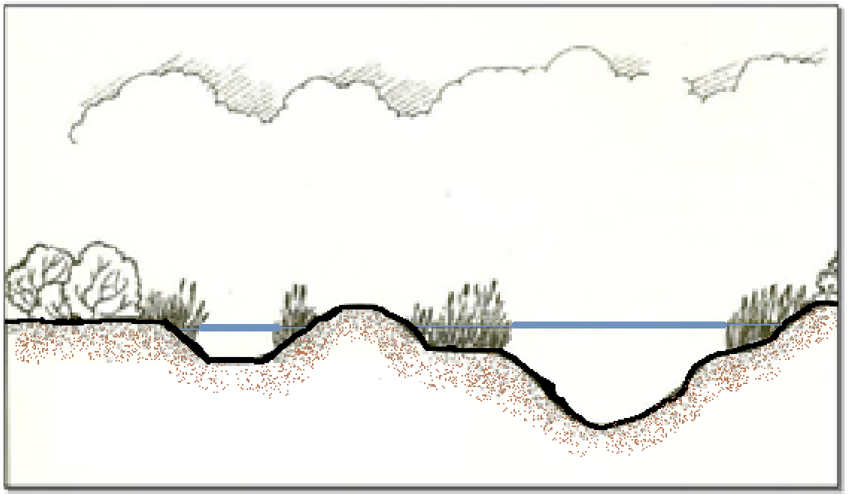

Figure 4: Example of irregular bottom contours for island habitats (not to scale).

1.1.5 Water Table Elevation

! The water level elevation included in the design dictates the elevations ascribed to the entire design since the water level will dictate the location of the design zones (Open Water, Marsh Plant, Riparian, Upland). Thus, once the elevation of the water table is determined, elevations can be added to the design.

! The more water table information that is available at the front end of the design process, the better the design. Surficial groundwater levels are highly affected by climatic fluctuations. Thus, the best data will be long-term water table data. To collect this information, **we recommend installing long-term water table monitoring wells at sites that are planned to be reclaimed to water bodies.** If long-term water table data are available, the design can include water table fluctuation ranges, which is highly informative for the proper placement of water body zones.

- If possible, install monitoring wells around the site to determine water levels (surface water and ground water). Wells must be constructed in a way that minimizes disturbance and are adequately sealed and developed. Data collection should be done multiple times over the year preferably for multiple years to reflect seasonal fluctuations in the water table (Aller et al., 1991). The amount and location of wells will be based on the extent of the site, general site conditions, surface and subsurface geologic conditions, and properties of the aquifer.

- Ground Penetrating Radar can be used as an alternative method to determine water table elevation. Electromagnetic waves and indices of refraction can be used to delineate subsurface features. Materials containing water produce strong reflections in the EM wave. Data collection is done by moving a radar and datalogger along transects. Data are interpreted via changes in the relative permeability of the subsurface (Mau et al., 2014).

- When a high degree of certainty is required, a combination of methods can be utilized to create a more comprehensive understanding of the water table.

- Nothing replaces monitoring well data. However, if long-term data are not available, a desktop study can be conducted using available information such as topographic and geologic maps, hydrogeologic reports, geotechnical investigations, water well databases, borehole data, and any other relevant, accessible sources.

    - Create a geodatabase of water table elevation point data. Drillers will often note the depth of the water table while conducting borehole investigations. Water table information from soil pits dug during environmental assessments can also provide a source of data. LiDAR elevations from nearby surface water can also be used since the presence of surface water bodies indicates where the water table intersects the land surface.

    - Once hydrological data are collected, multiple transects across the site can be drawn and water table cross-sections can be created, which indicate water table depth (for example, see Figure 5). The highest water table elevation to enter the pit can be used in the design.

1.1.6 Water Level Control

! Climate, geology, topography, and vegetation will affect the volume and rate of water entering a water body. Water may enter the water body through multiple pathways, including direct precipitation, watershed runoff, local groundwater, and regional groundwater. Due to the complexity of water movement on the landscape and variable and un-predictable long-term climate, it can be very challenging to accurately predict water level variation in a water body. Since plant species have very specific tolerance ranges to moisture, abrupt changes in water levels can have dramatic impacts to revegetated areas and the project in general. The following mitigation measures can reduce the potential risk of acute changes in water levels on project outcomes:

- ✓ Design the maximum depth of the Marsh Plant Zone at least 1m below the Normal Water Level. This will ensure the continued presence of the Marsh Plant Zone during dry cycles.

- ✓ Design the Riparian edge of the Marsh Plant Zone 0.5m above the Normal Water Level. This will create some space for the Wet Meadow Zone in case water levels are higher than anticipated.

- ✓ If placing an outlet, place the outlet elevation at 0.5m above the Normal Water Level to prevent excessive flooding of the Marsh Plant Zone. Aquatic Plants cannot withstand water level fluctuations greater than 0.5m (CEMA, 2014). For further design guidance on outlets, see CEMA (2014).

Outlets should be designed to be self-sustaining as much as possible, though it may take several years of maintenance to address sediment accumulation and bring outlets to proper operation. Note: According to the *EPEA Conservation and Reclamation Regulation (Alberta Queen's Printer, 2016)*, an application for a reclamation certificate must contain "documentation of and justification for any surface improvements to be left on the conserved and reclaimed land and written acceptance of the improvements by the registered owners of the land."

Step 1.2 Design Assessment

1.2.1 Materials Balance

Purpose: Determine if the initial design can be supported by available on-site reclamation material.

Guidance:

- ✓ Determine the volume of onsite topsoil and subsoil that are available for reclamation.
- See soil Step 1.4 – Soil Prescription Plan for recommended soil placement depths to allow completion of the materials balance.
- Historical soil salvage and practices at the time of salvage will dictate available material.
- If there is a shortfall of reclamation material on-site, alternative sources might be available or initial reclamation design will need to change (e.g. larger open water areas, fewer island habitats). If soil is needed from another disposition, regulatory authorization may be required.

1.2.2 Hydrology

Purpose: Determine hydrologic sustainability of the design through calculation of the water balance.

Guidance:

- ✓ A water balance equation can be used to describe the flow of water in and out of the water body and it is an important tool for understanding and managing interactions between climate and geology (Devito & Mendoza, 2006). Water may enter the water body through precipitation, watershed runoff, and/or groundwater discharge. Water may leave the water body through outflow, groundwater recharge, evaporation from the open water zone, and/or transpiration from the vegetation. Water body viability can be determined by evaluating the inputs and outputs defined by the water balance equation, as follows.
  - $\Delta S = P - ET + (R_{in} - R_{out}) + (GW_{in} - GW_{out})$ where: ΔS is the change in storage, P is precipitation, ET is evapotranspiration, R is runoff, and GW is groundwater.
  - Morton's method (Alberta Environment and Parks, 2016) can be used if groundwater inputs/outputs are negligible or if they are balanced ($GW_{in} \approx GW_{out}$).
- ! An understanding of hydrogeological site characteristics is necessary to create a realistic water balance. Depending on the underlying geology, landscape position, water table elevation, and the presence of inflows and outflows, the presence and magnitude of surface and groundwater inflows/outflows will differ from one site to the next (Figure 6). There are two major hydraulic types of water bodies, dependent on the surface and groundwater flows: drainage types have a surface water inlet and outlet, whereas seepage types do not. Seepage types are further subdivided into recharge, flow-through, and discharge types based on the patterns of groundwater flow (Figure 6). **It is important to characterize the site into its proper hydrologic type to guide the creation of the conceptual water balance model.**

! Climate is the chief controlling factor of an eco-hydrologic design (Devito & Mendoza, 2012). Consider that:

- Water deficits and surpluses in water bodies vary intra-annually with seasonal changes in precipitation and evapotranspiration.
- Water deficits and surpluses in water bodies vary inter-annually with decadal and multi-decadal precipitation cycles.
- Deviations from the average conditions are of utmost importance to water body functionality and accounting for them when designing constructed water bodies is critical.
- Long term datasets are fundamental to characterizing the setting for a constructed water body.

A water balance is a requirement as part of the Water Act Application package, where applicable (AEP, 2015; Table 1).

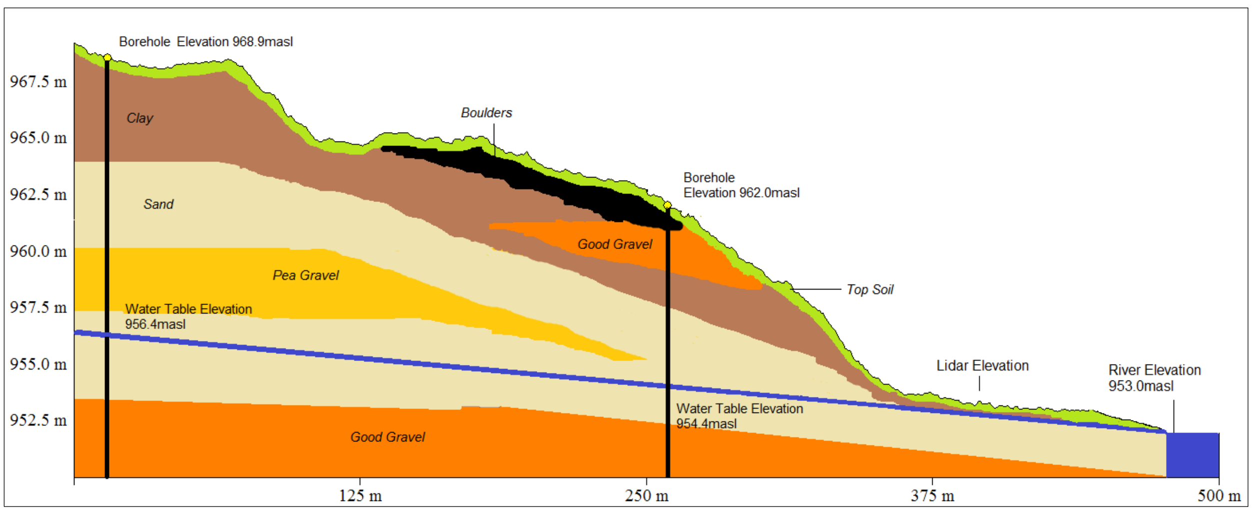

Figure 5: Example of a water table elevation cross-section. This example is for a gravel pit exploration area. For a borrow excavation, the underlying soils and geology will be different, but the concepts associated with determining water table depth will be similar.

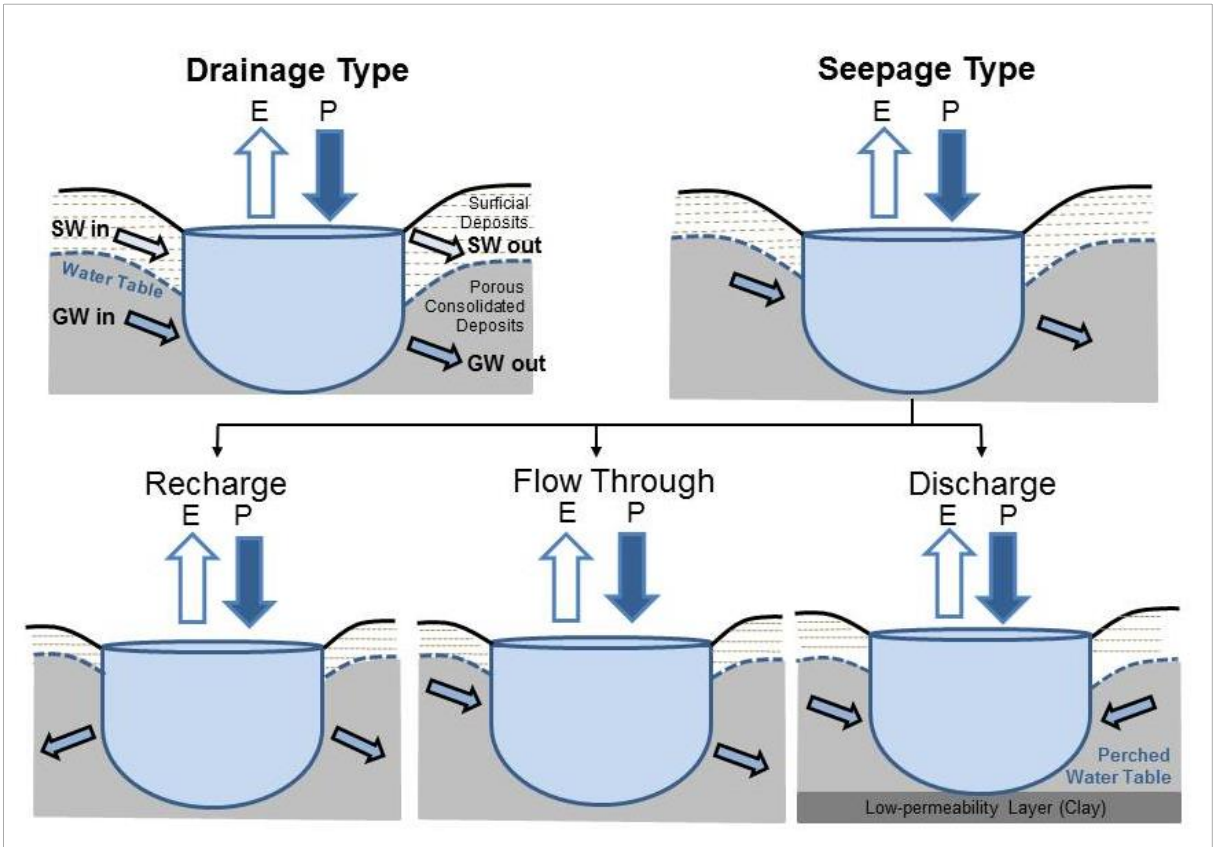

Figure 6: Hydrologic types of water bodies (modified from Webster et al., 2006). SW = surface water. GW = groundwater.

1.2.3 Geotechnical

- ✓ A geotechnical engineer should review the design to review earthworks designs, evaluate the stability of slopes, and assess risks posed by site conditions.

Step 1.3 Final Design

1.3.1 Final Design Drawings

Purpose: Development of a water body final design.

Guidance:

- ✓ Based on the materials balance, the water balance, and geotechnical constraints, the design is revised and elevation contours are produced. At this point, a final reclamation topography map and cross-sections can be produced. See Figures 7 and 8 for examples.

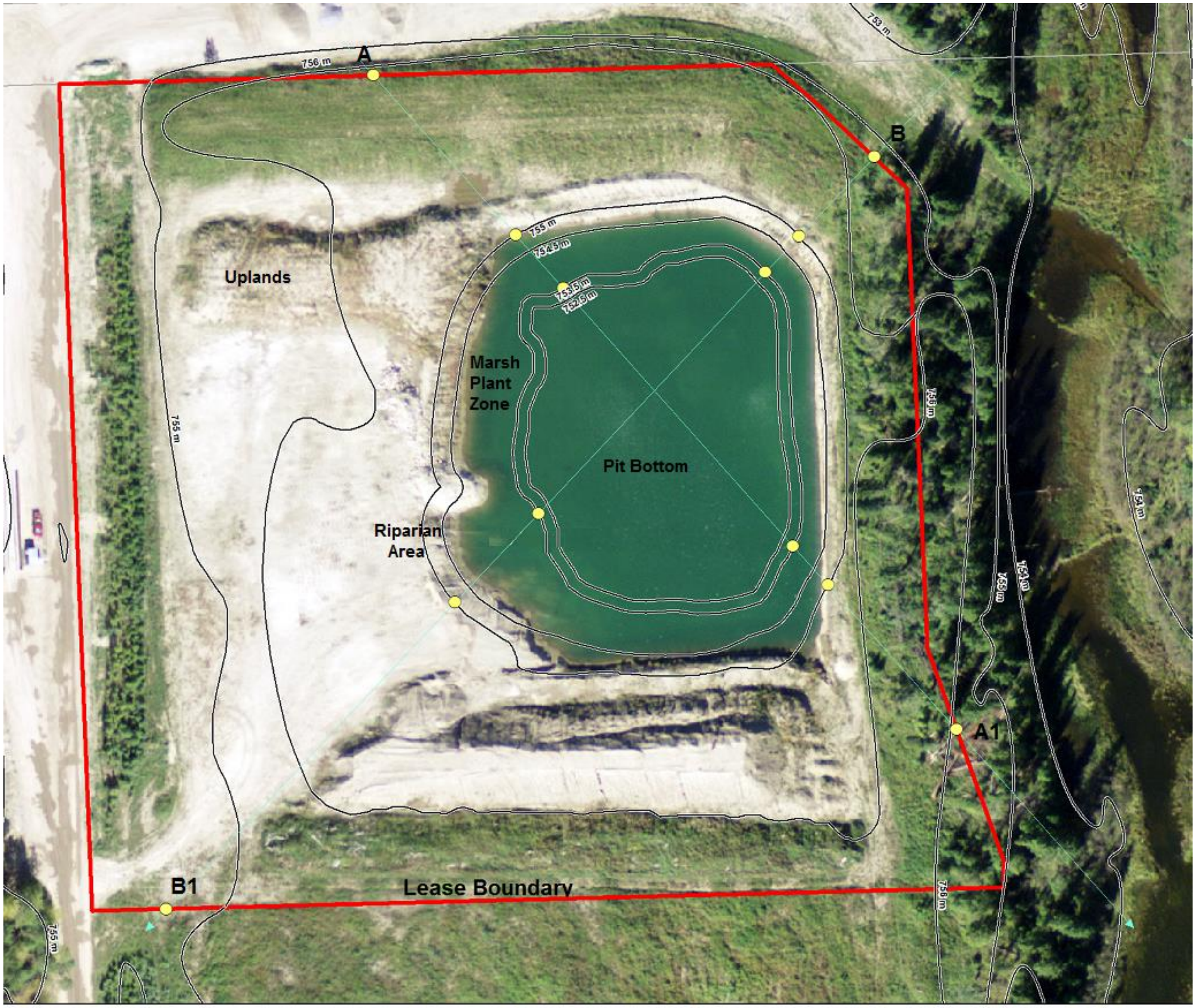

Figure 7: Conceptual final water body drawing with topography and cross section outline

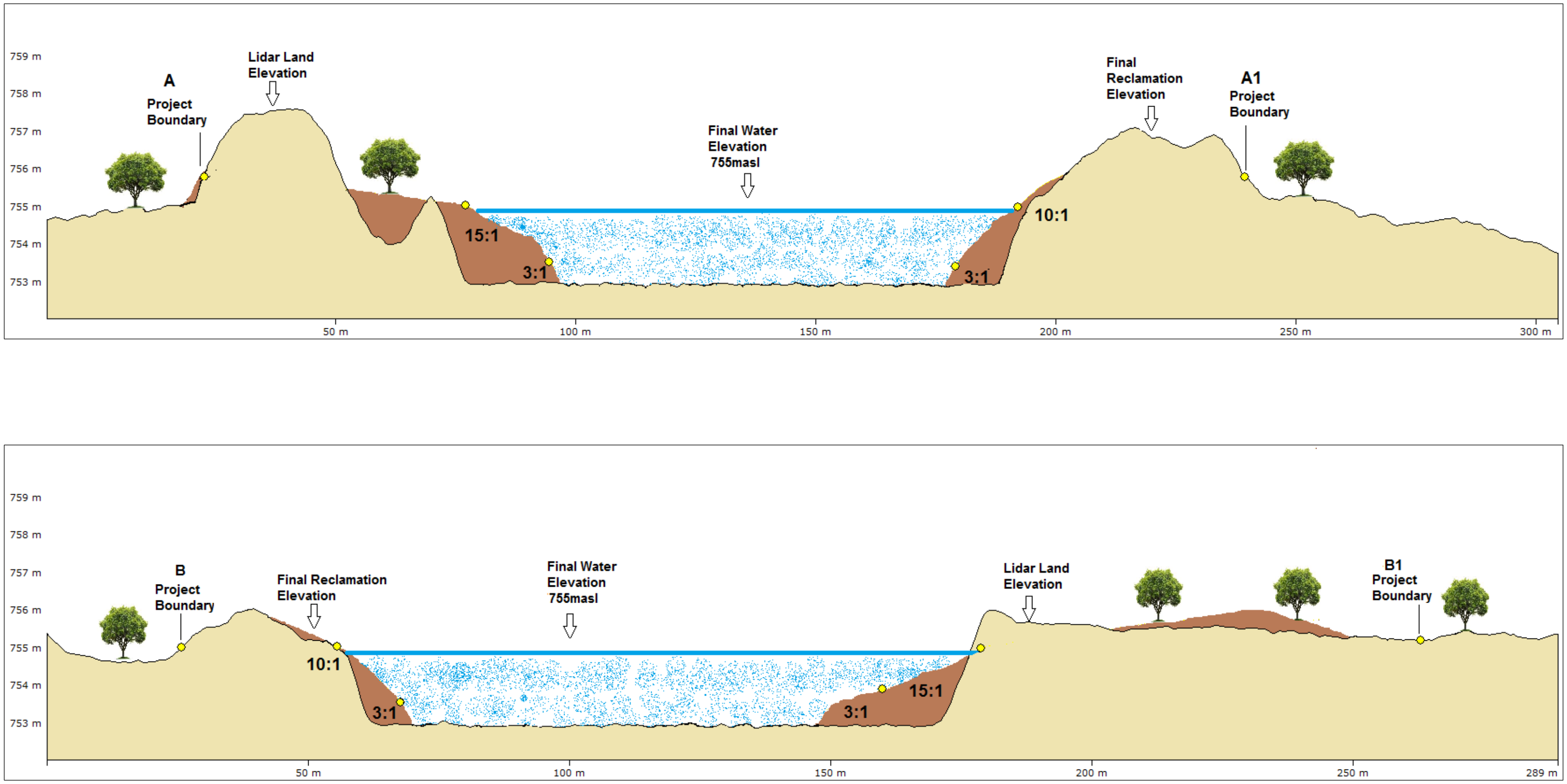

Figure 8: Example cross-sections - initial land elevations, final reclaimed water body slopes, and final water elevation. Note that there is considerable vertical exaggeration; distances and slopes are not to scale.

Step 1.4 Soil Prescription Plan

1.4.1 Determine Water Body Zone Area and Final Placement Depths

Purpose: Soil placement prescriptions will support "equivalent land capability" or the ability of land to support various land uses after conservation and reclamation, by providing soils on which aquatic plants can develop.

Guidance:

Consider the following guidance to determine soil volumes needed for each water body zone area.

In All Areas:

- ✓ Reclamation material should be placed in all water body zones if possible. Current research does not yet dictate specific best placement depths by water body zone.
- ✓ Soil quality assessment may provide additional information with respect to the suitability of soils to support vegetation communities. The soil quality of stockpiles (from the materials balance) or other available material can be conducted as per Soil Suitability Criteria (Agriculture, Food, and Rural Development, 2004) and Table 3. Table 3 was developed as a guide for key soil quality parameters "good", "fair", and "poor" soils specifically for wetland environments (Ross & Gabruch, 2015). Ideally, practitioners will have "good" quality material at their disposal and use this for reclamation. However, if the only material available may be of "poor" quality, adjustments to the reclamation plan may be necessary to ensure vegetative success (e.g., adjust plant selection for salinity tolerance, add soil amendment, etc).
- ! The soil material available on site may not have previously supported aquatic vegetation, and may have been upland soil or a combination of upland/wetland soils. As such, the properties of the reclamation soil may not conform to the soil quality guidelines presented here. This will not prohibit successful aquatic reclamation, but plant community composition may be initially different than expected from natural aquatic analogues.
- Average topsoil placement depth should reflect depths at existing natural mineral aquatic analogues on the landscape, and consider all regulatory direction, including authorized PLCRCPs and the project-level material balance.
- Where compaction may be a potential concern in the future, consider using denser material (1.4 to 1.85 g/cm^3) to reduce the potential for compaction (Ross & Gabruch, 2015).
- ✓ Table 4 contains a list of Best Management Practices (BMPs) regarding soils to support the ecological quality and revegetation success.

Marsh Plant Zone

- ! The Marsh Plant Zone is where re-vegetation efforts will be focused. If there is a shortfall of soils, soil placement should be focused on the Marsh Plant Zone.

- ✓ To promote root penetration into the soil, an adequate rooting zone should be established. Available salvaged topsoil and subsoil on site will be used for soil placement. We present the following guidance as BMPs only, recognizing the limitations of available material at the site. Where possible, it is recommended to place a minimum of 60cm of "good" and "fair" quality soil (subsoil + topsoil; Table 4) as follows: 25-40cm of topsoil (Ross & Gabruch, 2015) and a minimum of 30cm of subsoil (Drozdowski & Macyk, 2008). However, these depths may not be possible at all sites, as the volumes of soil that can be placed will depend on the materials balance; therefore, these depths should be interpreted as BMPs.

- Topsoil includes components of all organic horizons and/or the "A" horizon as defined by the *Canadian System of Soil Classification (1998).* If topsoil has been specifically defined in the EPEA approval, this definition should be followed. Organic material can come from existing non-weedy vegetation growing onsite (stripped prior to operation).

Table 3: Recommended aquatic soil quality parameters (Ross & Gabruch, 2015). Categories are based on Soil Suitability Criteria (Agriculture, Food, and Rural Development, 2004).

Parameter	Good	Fair	Poor
pH	6.5 to 7.5	5.5 to 6.4 and 7.6 to 8.0	4.5 to 5.4 and 8.1 to 8.5
Salinity/ Conductivity (dS/cm)	<2	2 to 4	5 to 8
Sodicity (SAR)	<4	4 to 8	9 to 12
Organic Matter (%)	6 to 12	5	<5

Table 4: Best management practices (BMPs) for soils to support aquatic ecological quality and reclamation success (Ross & Gabruch, 2015).

Property	BMP
Texture	Finer-textured soils are preferred
Moist Consistency	Friable materials are preferred
Bulk Density	1.35 g/cm^3 is preferred, and soils should not be compacted during placement; however, if compaction may be a potential future issue, consider using denser material (1.4 to 1.85 g/cm^3) to reduce the potential for compaction
Available Rooting Zone	At least 60 cm (surface soil and subsoil combined) is preferred to promote root penetration and support revegetation success.
Application Depth of Surface Soils	If required, 30 to 50 cm of surface soils are preferred for soil-like subsoils; at least 70 cm are preferred for sodic subsoils
Soil Stockpile Age	Shorter stockpiling times are preferred to maintain propagule viability and OM content
Erosion Control Activities	Conducting activities that keep soil particles from being eroded by wind or water during the design phase (prior to site construction) are preferred (proactive approach)

Step 1.5 Revegetation Planning

1.5.1 Plant Species Selection

Purpose: Plant species chosen are appropriate for water depths expected, consistent with growing conditions on the reclaimed site, and in accordance with the composition and relative abundances found at similar water bodies in the adjacent landscape (Boreal Research Institute, 2011).

Guidance:

- ! Propagation of boreal aquatic plant species is an emerging and continuously evolving field of study – it is in an active research phase. We recommend that the list of species and techniques presented in this document be updated regularly to reflect the evolving nature of boreal aquatic plant re-vegetation.
- ✓ Efforts should be made to establish a broad assortment of aquatic species. Diversity builds functional redundancy, which makes the site more resilient against unexpected disturbances.
- ✓ Re-vegetation should focus on the Wet Meadow Zone and the adjacent Riparian Zone (see Table 5). The Emergent Plant Zone and Shallow Open Water Zone plants tend to come in on their own (natural ingress; Galatowitsch & Van der Valk, 1998). Cattail (*Typha spp.)* should not be planted anywhere in the water body, as it will emerge on its own – in fact, it may need to be managed due to its competitive nature.
- ✓ Appendix 3 lists species (or genus) - specific planting techniques which are relatively well-studied; thus, these species and associated planting techniques can be recommended at this time.
- ✓ Plant species should be appropriate for the expected water depths. See Appendix 3 for a list of species (or genus) and the different possible water depth ranges (i.e., plant zone).
- ✓ Plant species should be consistent with the vegetation of corresponding nearby aquatic site types. Review pre-disturbance assessments and/or perform species surveys to determine appropriate species for the area.

Table 5: Description of vegetation types (CEMA, 2014).

Vegetation Zone	Description
Riparian Zone	Contain plants associated with both aquatic and upland environments; the transition between water to land. Vegetation and soils are strongly influenced by the presence of water, includes trees, grasses, shrubs.
Wet Meadow Zone (water level 0.1 - 0.2m)	Includes upright plants rooted in substrate beneath the water or exposed to seasonal flooding but emerging above water surface. Inability to tolerate deep flooded environments.
Emergent Zone (water level 0.2 - 1m)	Includes upright plants rooted in substrate or exposed to seasonal flooding but emerging above the surface. Tolerates deeper flooding than species that occupy the Wet Meadow Zone. Does not include submerged or floating-leafed plants.

1.5.2 Determine Plant Collection and Establishment Methods

Purpose: Determining plant collection and establishment methods will assist in establishing a revegetation schedule.

Guidance:

- Table 6 lists all possible plant establishment techniques, as well as considerations for their use. If natural ingress or donor soil is chosen as a revegetation technique, no species selection needs to take place. For all other techniques, species selection is required.

✓ Review

✓ *Appendix 3: Recommended Establishment Techniques for Selected Aquatic* Species for recommended planting techniques.

✓ See Section 4.1 Site Revegetation for general planting densities, if collecting seeds/plants.

Seed/Seedling Collection

✓ Follow *Native Plant Revegetation Guidelines for Alberta* (Native Plant Working Group, 2001). Additional plant material collection techniques can be found in *Seeds Collection, Processing and Storage* (Smreciu & Sobze, 2011) and *Native Boreal Shrub Seed Collection and Cleaning* (Schoonmaker, Marenholtz, & Sobze, 2014).

▽ All trees and shrubs collected from the Green Zone is governed through *Alberta Forest Genetic Resource Management and Conservation Standards* (FGRMS) and standards for collection, handling, registration and storage is found in this document and should be reviewed prior to collection activity (Alberta Agriculture and Forestry, 2016). Seeds collected from tree and shrubs need to be from within applicable Seed Zone of the areas to be revegetated. Although aquatic and riparian material is not required to follow FGRMS, it is good practice to collect this material locally.

▽ Plants harvested from public lands or destined for placement on public lands must be registered with Alberta Tree Improvement and Seed Centre.

▽ On public land, a Temporary Field Authorization for seed/seedling collection is required (i.e., a TFA). Consult the local AEP office for requirements. Generally, a plan is submitted to the appropriate agency detailing the area to be harvested, method of harvesting, timing of harvesting, and the target species. After harvesting, the proponent submits a report to the appropriate field office identifying the actual areas harvested (on a map) and the approximate yield/volume of seed/plant parts.

Shallow Water/Emergent Zone

- The Shallow Open Water Zone may be difficult to revegetate due to water depth. Thus, natural ingress is often the preferred option for establishment of this zone.

- Planting has been successful for revegetation of the Emergent Zone (Clarkson & Peters, 2012). However, plants will readily revegetate the Emergent Zone through natural ingress (Galatowitsch & Van der Valk, 1998). Planting may be a good option for adding diversity to the plant community.

Wet Meadow Zone

✓ We recommend that plant establishment focus on the Wet Meadow Zone, since this area is the most difficult to re-vegetate and most prone to weed invasions. Recommended establishment techniques are species specific (see Appendix 3).

- Sedges typically dominate Wet Meadow Zone plant communities. Seeding sedges is not recommended due to very low germination rates as compared to the effort involved in seed collection. Using donor soil and/or planting can be used for sedge propagation. The only groups of plants where seeding may be a preferred option are grasses (Appendix 3). Otherwise, seeding is not recommended.

Riparian Zone

✓ See *Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region (2010)* and the *Riparian Classification and Reclamation Guide – Revised Edition (CEMA 2012b)*.

Table 6: Considerations when choosing aquatic vegetation establishment techniques.

Technique	Considerations
Planting: greenhouse-supplied seedlings	• Cost: High. Labor required to plant. May require seed collection that must be completed the fall before; seeds must be stratified for 30 or more days during late fall, depending on greenhouse plant availability (some species may not require stratification). Plant shipping costs must be considered. • Mortality: Low. Note that revegetating water bodies with nursery-grown plugs has resulted in a higher establishment rate than with seeding or transplanted plants (Urban Drainage and Flood Control District, 2016) • Practicality: Requires coordination with one or more greenhouse(s), depending on available greenhouse space. Plant care (watering) may be required until planting. • Site prep needs: Works well where water levels/availability in the spring may fluctuate. • Scheduling: Planting of greenhouse stock can be completed in one to two months in the spring/early summer. One-year old seedlings are small and easily handled. • Availability: Nursery grown stock is of consistent quality though not all species are available. Seed collection and delivery to greenhouse may be required, depending on desired species. Check greenhouses for availability.

Technique	Considerations
Planting: transplanting plants collected from a donor site	• Cost: Moderate to High. Labor required to collect and transplant. Site access and plant transportation costs must be considered. • Mortality: Low. • Practicality: Plant care (watering) may be required until planting. Plants need to come from similar sites. • Site prep needs: Generally, 13-15cm plug depth is all that is needed from the donor site (Hoag, 2000). Cores should be at least 10cm in diameter. Works well where water levels/availability in the spring may fluctuate. • Scheduling: Window of transplant is one to two months in the spring/early summer. Plant collection must be scheduled within days of transplanting. • Availability: Site-specific - depends of availability of nearby donor sites. Field reconnaissance required prior to plant collection.
Donor soil placement	• Cost: High. Equipment costs for stripping, moving, and placing soils. • Mortality: Moderate but at this stage in the research seemingly successful. • Practicality: Access to donor site may be challenging. May need Water Act and Public Lands Act (TFA) Approvals if going off surface lease. This can take roughly 6 months. • Site prep needs: Collect the top 13-15cm of wetland donor soil including plant roots, tubers, rhizomes, stalks and seeds. Dig no more than 0.09 m^2 of donor plant material from a 0.4 m^2 donor area (Hoag, 2000). Water levels at recipient site need to cover at least the roots of the vegetation deposited. • Scheduling: Harvest when soils are moist but well-drained (Urban Drainage and Flood Control District, 2016). • Availability: Depends on proximity of donor site. Donor site needs to be similar in species and chemistry of area of created water body.
Natural Ingress	• Cost: Low cost but unpredictable results. • Practicality: May need to manage for aggressive plant species. Risk that desired species may not establish. Less consistent mode of recovery with increasing degree and duration of soil disturbance (and thus greater chance of weed colonization). • Site Prep Needs: None (though propagule establishment success can be improved with techniques such as placing CWM to create microsites and reduce erosion (Pyper and Vinge, 2012))

Although we include information on seeding, this method is not recommended to be used on its own due to very low germination rates as compared to the effort involved in seed collection.

Technique	Considerations
Seeding: greenhouse stratification	• Cost: Moderate. Costs will depend largely on availability and cost of seed of target species (Schoonmaker & et. al. , 2014) • Mortality: Predictability of results is low for many non-grass species – low germination

Technique	Considerations
	rate (5% or less). Thus, use of this technique is questionable in many cases. • Practicality: Straightforward - requires no specialized equipment. • Site prep needs: Water levels need to be managed to be of appropriate depth (see Appendix 3). Soil must be wet during germination, but not flooded. Surfaces roughened. • Scheduling: Can be completed within 4-5 months, but seeds spread in fall/early winter before snow. Seeds collected in August-September, stratified for 30 days and spread in early winter when site is frozen (some species may not require stratification). • Availability: Site-specific - depends of availability in nearby donor sites, but species are common and abundant in most areas. Field reconnaissance is required prior to plant collection to locate donor sites.
Seeding: natural stratification	• Cost: Moderate. Costs will depend largely on availability and cost of seed of target species (Schoonmaker & et. al. , 2014) • Mortality: Predictability of results is low and germination rates are low for non-grass species (5% or less). Thus, use of this technique is questionable in many cases. • Practicality: Requires coordination. Seeds may take more than one year to germinate. • Site prep needs: Water levels need to be managed to be of appropriate depth (see Appendix 3). Soils must be wet during germination, but not flooded. Surfaces roughened. • Scheduling: Least time-consuming from seed collection in Aug-Sept to seed spreading in Oct after which the seeds naturally stratify. • Availability: Site-specific - depends of availability in nearby donor sites. Field reconnaissance may be required prior to plant collection.

1.5.3 Scheduling Revegetation

Purpose: Successful revegetation involves the identification, sourcing, and collection/ordering of seeds, seedlings, and propagules so that they can be available when it is time to revegetate the water body, riparian zones, and surrounding areas. This process can take up to two years. Scheduling ensures that revegetation activities are appropriately sequenced and efficient.

Guidance:

- ✓ Lead time of approximately one year is required for the production of most forbs. Lead time for shrubs and trees is longer (Native Plant Working Group, 2001).
- ✓ Potential seed collecting stands should be field-scouted prior to actual seed collection, approximately 3-4 weeks before the fruits are ripe (Schoonmaker A. , Marenholtz, Sobze, & Smreciu, 2014).
- ✓ Revegetation scheduling, based on establishment technique, is presented in Tables 7, 8, and 9.

Table 7: Timeline for revegetation using seeds.

Seeding – greenhouse stratification		**Seeding – natural stratification**	
Late summer/Fall (Yr 1)**	Collect seeds	**Late summer/Fall** (Yr 1)**	Collect seeds
Winter (Yr 1)/Spring (Yr 2)	Stratify (30-60 days)	**Fall/early winter (Yr 1)**	Site preparation*
Late Fall (Yr 2)	Site preparation*	**Fall/early winter (Yr 1)**	Spread seeds
Late Fall (Yr 2)	Spread seeds		

**Includes soils placement, amendments, roughing*
***June -August for collection of most berry and grass seeds* (Boreal Research Institute, 2016).

Table 8: Timeline for revegetation using seedlings.

Planting – nursery / greenhouse stock		**Planting - transplanting from Donor Site**	
Late summer/Fall (Yr 1)	Collect seeds	**Fall/Winter (Yr 1)**	Site preparation**
Fall (Yr 1)	Provide seeds to supplier of seedlings*	**Early spring (Yr 2)**	Collect native seedlings
Fall/winter (Yr 1)	Site preparation**	**Late spring (Yr 2)**	Seedling planting
Winter (Yr 1)	Stratification/germination		
Spring (Yr 2)	Seedlings delivered to site		
Late spring (Yr 2)	Seedling planting		

** This may be done by the supplier in some cases.*
***Includes soils placement, amendments, roughing*

Table 9: Timeline for revegetation using donor material.

Use of Donor Soil	
Spring/Early Summer (Yr 1)	Select donor site
Spring/Early Summer (Yr 1)	Collect donor soils
Spring/Early Summer (Yr 1)	Immediate placement upon removal

Step 1.6 Site Preparation

Purpose: Water management in preparation for earthworks, if required.

Guidance:

- Temporary ditching and/or pumping may be necessary in some cases to remove water from the worksite and allow construction activities.

- If pit dewatering is necessary, the proponent should review the Water Ministerial Regulation (Government of Alberta, 2000) and consult with the responsible regulatory agency to determine whether an approval and/or license under the Water Act are required.

Step 1.7 Reclamation Construction Package

Purpose: Compile the final design, soil prescription, and any safety related plans for the formal Reclamation Construction Package to be communicated with the construction crews.

Guidance:

Final Drawings

✓ Upon completion of the final design, the soil prescription, and planning for revegetation, drawings to guide construction should be developed. Drawings may include:

- Regrading areas
- Fill placement and excavation areas
- Inlet and outlet locations
- Topography of water body and surrounding areas
- Reclamation material placement
- Revegetation areas/plant zone delineation

Construction Package

- The Construction Package is critical to provide direction to the construction team, minimize disturbance, and conserve the site during construction. The site-specific Construction Package must be aligned with the CRBP or PLCRCP

The Construction Package must be retained for the life of the overall project and must be available upon request by the Regulator (AER, 2016).

✓ The Construction Package should include, at a minimum:

- Final drawings (see above)
- Construction techniques
- Identification of environmentally sensitive areas within or beside the planned area of disturbance
- Mitigation measures to protect environmentally sensitive areas. For example:
    - Buffers and setbacks along sensitive areas
    - Refueling setbacks from watercourses and waterbodies
    - Spill detection and response
    - Erosion/sedimentation control measures
- Roles and responsibilities, chain of command, and contact information

✓ The construction package must be communicated with the construction team to ensure transfer and understanding of project information.

Reclamation Milestone 2: Landform Construction & Soil Placement

Upon completion of the Milestone 1, landform construction can begin. Tasks involved in landform construction and soil placement include: rough grading and recontouring, placing the inlet(s)/outlet(s), developing erosion controls, de-compaction, and placing soils.

Milestone 2	Step 2.1: Earthworks and Construction	Communicate construction package to construction crews
		Install mitigation controls
		Site grading & re-contouring
		Decompaction/roughing
	Step 2.2 Soil Placement	Topsoil & Subsoil Placement
		Soil Treatments and Amendments

Step 2.1 Earthworks and Construction

Purpose: Implementation of the construction package and place the landform slopes and contours before soil placement.

Guidance:

- ✓ Communicate the final drawings and construction package to the construction crews to address remaining questions and ensure there are no outstanding issues.
- ✓ Layout and staking as per Final Drawings, which will guide equipment operators.
- ✓ Install any mitigation controls identified in the construction package.
- Soft ground can preclude the use of large equipment. Typical equipment includes tracked dozers, excavators, trucks and graders (CEMA, 2014).
- Rough and loose surface treatments provide an effective way to control erosion, create conditions that promote the revegetation of the site, increase biodiversity and improve ecological resilience (Polster, 2013).
- If de-compaction is necessary, consider ripping the soil where compaction exceeds build densities of 1.6 g/cm^3 (Ross & Gabruch, 2015) for all areas. However, ripping should not allow for the mixing of topsoil and subsoil. Methods can include:

- Ripping compacted surfaces to a depth of ≥30cm with a cultivator, discs or ripper teeth attached to a grader or bulldozer.

- In water-saturated zones, de-compaction does not require great depths (≤30cm).

Step 2.2 Soil Placement

Purpose: Topsoil and subsoil placement will aim to create a soil profile suitable for plant establishment, while meeting EPEA approval conditions.

Guidance:

✓ Follow soil prescription plan (Section 2, Step 1.4) and BMPs from Table 4.

✓ Placement of topsoil during frozen ground conditions, though not over snow, to reduce potential for over-compaction or in the spring/summer during dry ground conditions.

✓ Use a "rough and loose" approach with undulation depths of 10cm to 50cm to create areas of micro-diversity, with small ridges or knolls, mounds, or shallow depressions (Polster, 2013), which will enhance native seed catch, increase germination, support the emergence of propagules, maintain soil moisture, control erosion, and to create habitat for small mammals and soil fauna.

Step 2.3 Soil Treatments and Amendments

Purpose: To enhance soil nutrients, capture of moisture, protect against erosion, protect seeds/seedlings, and increase diversity.

Guidance:

- Addition of soil treatments and amendments may be used on a site-by-site basis. If soil is ripped and woody material is placed, additions may not be necessary.

  Coarse Woody Material (CWM)

  - CWM placed on top of the topsoil layer will add diversity and microsites to the landscape or can reduce and control erosion.

  - CWM is a cheaper amendment than fine wood chips (mulch) and is generally more conducive to supporting regeneration (Pyper and Vinge, 2012)

  ✓ Placement target max of 10-20% ground cover of CWM (CEMA, 2014), <5cm depth (Golder Associates, 2010).

    Marsh Plant Zone

    - Some stockpiled woody and reject material (i.e., rocks) may be incorporated into the marsh plant zone to provide additional organics and habitat development opportunities.

- Large woody material which extends from above the water line and into the marsh plan zone may provide good resting areas for waterfowl.

Erosion Control

- Use of erosion blankets if seeding upland slopes - Lay preferably no more than 24 hours after seeding along upland slopes subject to erosion (Golder Associates, 2010).
- Installation of silt fencing along the toe of slopes can be advantageous until vegetation is adequately established.
- Use of aggregate or rip-rap along sections of shoreline that have higher probability of erosion (e.g., exposed to greater amounts of wave action due to prevailing winds).
- Spread CWM, as described above.
- Inspect and maintain erosion control features regularly, to prevent future erosion. Leaving the soil rough will reduce runoff velocity, trap sediments, and increase infiltration (Ross & Gabruch, 2015).

Reclamation Milestone 3: Vegetation Establishment

The goal of vegetation establishment is the creation of a self-sustaining plant community that is compatible with the surrounding land use and includes plants that area native to the area (Alberta Environment, 2003). Wildlife habitat and ecosystem functions are dependent on appropriate site structure (vegetation) and desirable aquatic plant species. Undesirable species (upland species, weeds) are restricted by the establishment of desirable aquatic species. This chapter includes the steps and tasks leading up to successful aquatic plant establishment, including establishing the plants and vegetation management.

Milestone 3		
	Step 3.1 Site Revegetation	Acquire stocks/seeds
		Implement the revegetation plan
	Step 3.2 Establishment Controls	Manage for weeds
		Manage for wildlife interference

Step 3.1 Site Revegetation

Purpose: To implement the revegetation plan (see Step 1.5) and establish plants within the reclamation area.

Guidance:

- ✓ Follow the revegetation plan (Step 1.5) and guidance from Table 10. Table 10 includes planting strategies for seeding. However, seeding is not a recommended technique for any non-grass vegetation due to poor germination results (see Appendix 3). Plant distribution should simulate off-site occurrence of the species as much as possible (Native Plant Working Group, 2001).
- ✓ See Appendix 3 for recommended planting prescriptions for selected species.
- ✓ Plants and roots/rhizomes should be placed in holes dug in the mud. Roots/rhizomes of plants should be planted just below the soil surface and tamped in to ensure good soil contact (Urban Drainage and Flood Control District, 2016). See Appendix 3 for recommended planting depths.
- • Seed placement is dependent on species requirements, soil moisture and texture. Seeding too deep is a common cause of seeding failure. See Appendix 3 for recommended seeding depths.
- ! If using whole plants/seedlings, they need to have a portion of their leaves or stems above the water surface or they will drown (Clarkson & Peters, 2012).

Table 10: Aquatic vegetation establishment guidance.

Technique	Establishment Guidance
Planting: greenhouse-supplied seedlings	• Whole plants (20cm-30cm stems) or roots/rhizomes. • Planting densities between 2,000 and 5,000 plants per ha - Herbaceous: 2000-5000 stems/ha - Trees/Shrubs: 2000-4000 stems/ha - Sedge species: 4000-5000 seedlings/ha • CWM may be used (<5cm deep) but not required by whole plants. • Seedlings are best planted in late spring after frost has disappeared.
Planting: transplanting plants from a donor site	• Whole plants (20-30cm stems) or roots/rhizomes (13-15cm plug depth). • Cores from donor sites require a diameter of about 10cm. • Planting densities between 2,000 and 5,000 plants/ha - Sedge species: 4000-5000 seedlings/ha, - Shrubs: 2000-3000 plants/ha • All plant material should be re-planted in the same plant zone that it was removed from (Urban Drainage and Flood Control District, 2016).
Donor soil placement	• Should be placed immediately or stored less than one month. • Donor soil should be spread carefully at a thickness of 15cm or less. • Cover the roots of the vegetation by 2.5-5cm of water (Urban Drainage and Flood Control District, 2016).

Although we include information on seeding, this method is not recommended to be used on its own due to very low germination rates as compared to the effort involved in seed collection.

Seeding: greenhouse stratification or natural stratification	• Best used in combination with donor soil or plantings, sown after the soil/plantings have established (Clarkson & Peters, 2012). • Seeds most competitive with weeds should be sown first. • Best practice is to direct drill seed into soil in the fall, but can be broadcast from the ground, helicopter, or from the water. • Distribute in locations where the soil surface is exposed and the soil surface is tacky, and is not prone to flood. Seeds of most emergent and wet meadow species will not germinate underwater. Water levels may need to be lowered to facilitate seed germination (Galatowitsch & Van der Valk, 1998). • Follow up with a soil wetting, but not flooding, to ensure germination. • Generally, a seeding rate of 100-200 seeds/m^2 is recommended.

Step 3.2 Establishment Controls

Purpose: Active management of weed species and damage due to wildlife during reclamation will reduce the risk of impacts to native revegetation establishment.

Guidance:

Weeds

▽ An active monitoring program to control and destroy prohibited noxious and noxious weed species in accordance to the Weed Control Act is necessary for reclamation certification. The timing and approaches used to control noxious and prohibited noxious weeds depends on the species present, the development stage of the plant, and acceptable methods for control. Incorporate the site within the company weed control program.

! Pits that remain idle before reclamation should not be planted with clover or upland grasses.

- Water management (flooding or drying) can be used to control invasion of some aquatic and terrestrial species.

Wildlife Interference

- If wildlife is inhibiting vegetation establishment, the following methods may be used:
    - Use of temporary fences around the water body may be required to prevent wildlife grazing.
    - To prevent waterfowl from landing in the newly planted area and eating reclamation seeds, a placement of a wire grid system (3m on center) tied with brightly coloured flagging may reduce predation (Urban Drainage and Flood Control District, 2016). Alternative methods such as sonic deterrents or effigies of humans or raptors may also be effective.
    - If rodents (e.g. beaver, muskrat, etc.) are eating vegetation to the extent that it cannot re-establish, the animals may be trapped and relocated, with the appropriate authorization (CEMA, 2014). Contact the local Fish and Wildlife office.
    - Wire tree guards up to 1.5m high can limit beaver damage of tree/shrub species in riparian/upland areas (Urban Drainage and Flood Control District, 2016).

Reclamation Milestone 4: Reclamation Monitoring Plan

The success of aquatic reclamation will be largely evaluated based on the plant community. Early monitoring and management of the plant community will ensure that the investment in reclamation up to this point is maintained and the project is on the right trajectory.

Note: that this section does not preclude the requirements for EPEA related reclamation monitoring. This milestone outlines only monitoring for reclamation performance.

Milestone 4		
	Step 4.1: Develop Monitoring Plan	Develop monitoring plan
		Develop indicators
	Step 4.2: Monitoring & Focused Adaptive Management	Monitor to determine establishment success
		Adaptive management to solve or address issues

Step 4.1 Develop Monitoring Plan

Purpose: The goal of the monitoring plan is to keep the water body on a trajectory towards certification by demonstrating performance against design goals and objectives.

Guidance:

Monitoring Plan

! Monitoring should occur during and after the reclamation stage (Reclamation Milestone 2). In some cases, data collection that was begun prior to construction to inform the detailed reclamation plan will continue throughout the length of the project (e.g., water level measurement in wells). Monitoring during and after construction will provide early indications that design parameters or site expectations may need to be adjusted (see Step 4.2 – Adaptive Management).

✓ The monitoring plan should include:

- Overview of the monitoring program and monitoring objectives
- Study design
- Sampling protocols, including:

    - Location, number, and size of study plots.
    - List of Indicators and metrics (see below), rationale for indicator selection, and threshold effect levels.
    - Sampling methods.
    - QA/QC program.
    - Data analysis and interpretation methods
  - Monitoring reporting frequency
  - Description of the focussed adaptive management program (see Step 4.2) and how the monitoring results will be used to apply corrective measures.

Indicators

- As much as possible, metrics should be diagnostic, and should help identify if reclamation materials, water regime, or vegetation management (e.g., weeds) are causing issues.
- Metrics should indicate the degree of performance as measured against an established threshold.
- Table 11: Recommended water body establishment monitoring metrics and targets may be used to determine initial vegetation establishment success.

Table 11: Recommended water body establishment monitoring metrics and targets.

Component	Survey Metric	Measure
General maintenance	Weekly to monthly visual site inspections to document any potential issues, such as: • geotechnical • erosion • weeds • wildlife damage • inflow/outflow function • signage • public use • flooding • exposed soil	Level of maintenance and repairs declines with time.
Hydrology	Water table measurement.	Water levels (depth) consistent with design and expected plant zones
Soil	Bulk subsoil and topsoil placement at time of construction	In accordance with the Soil Prescription Plan (Step 1.4)
	Erosion throughout the life of the project	No visible signs of excessive erosion (rills, gullies, deposition)
Water quality	Routine chemistry (pH, EC,	Chemistry within the range of tolerance for selected

Component	Survey Metric	Measure
	conductivity, dissolved ions), turbidity, and total suspended solids	vegetation High turbidity and/or total suspended solids causing light limitation of plants or infilling with sediments
Vegetation	Native vegetation establishment (yrs 1&2)	Suitable germination of seeds or seedling establishment of desirable species.
	Native vegetation performance (yrs 3 to 5)	Diversity and abundance of desirable species.
	Growth of weeds & non-natives	Abundance (absence) of Prohibited and Noxious weeds
Wildlife	Waterbirds, waterfowl, amphibians, small mammals, large mammals	Evidence of presence/use, breeding and/or habitation.

Step 4.2 Monitoring and Focussed Adaptive Management

Purpose: Implement the Monitoring Plan, integrate monitoring results into management decisions, and take action in a timely manner to guide trajectories. Allow preparation of the application for reclamation certification.

Guidance:

✓ A reclamation monitoring operations plan should be created and communicated as appropriate to field crews. This plan will outline clear procedures and will contain forms to ensure collection of monitoring data in a consistent manner. Lack of consistency can cause an unnecessary increase in data variability, which can make data analysis and interpretation difficult.

! An adaptive management system should established and used in consultation with the responsible regulating authority, particularly if vegetation establishment is not meeting performance targets. Figure 9 presents an example of an adaptive management process.

- Monitoring of the vegetation establishment should occur for at least two growing seasons to ensure the plants are healthy (i.e., disease-free, appropriate colour, exhibits vigour, good height, etc). Areas that have been reworked due to vegetation shortfalls may be monitored for an additional two growing seasons to ensure corrective work was successful.

- Vegetation problems can be caused by unsuitable conditions for plant establishment and/or survival, or the establishment and spread of undesirable species. The site can be considered on the right trajectory if inhibitors, such as prohibited noxious/noxious weeds, are eliminated/controlled and if target species are establishing (see Table 11 for success measures).

- If the water body is to be used against wetland replacement liabilities (as per the Alberta Wetland Policy), wetland assessments must be signed off by a Registered Qualified Wetland Science Practitioner (QWSP) to ensure suitable progress, including stabilization, expected water levels, water flow, and vegetation establishment. If progress is not satisfactory, then additional actions may be required based on recommendations from a QWSP (Alberta Environment and Parks, 2014).

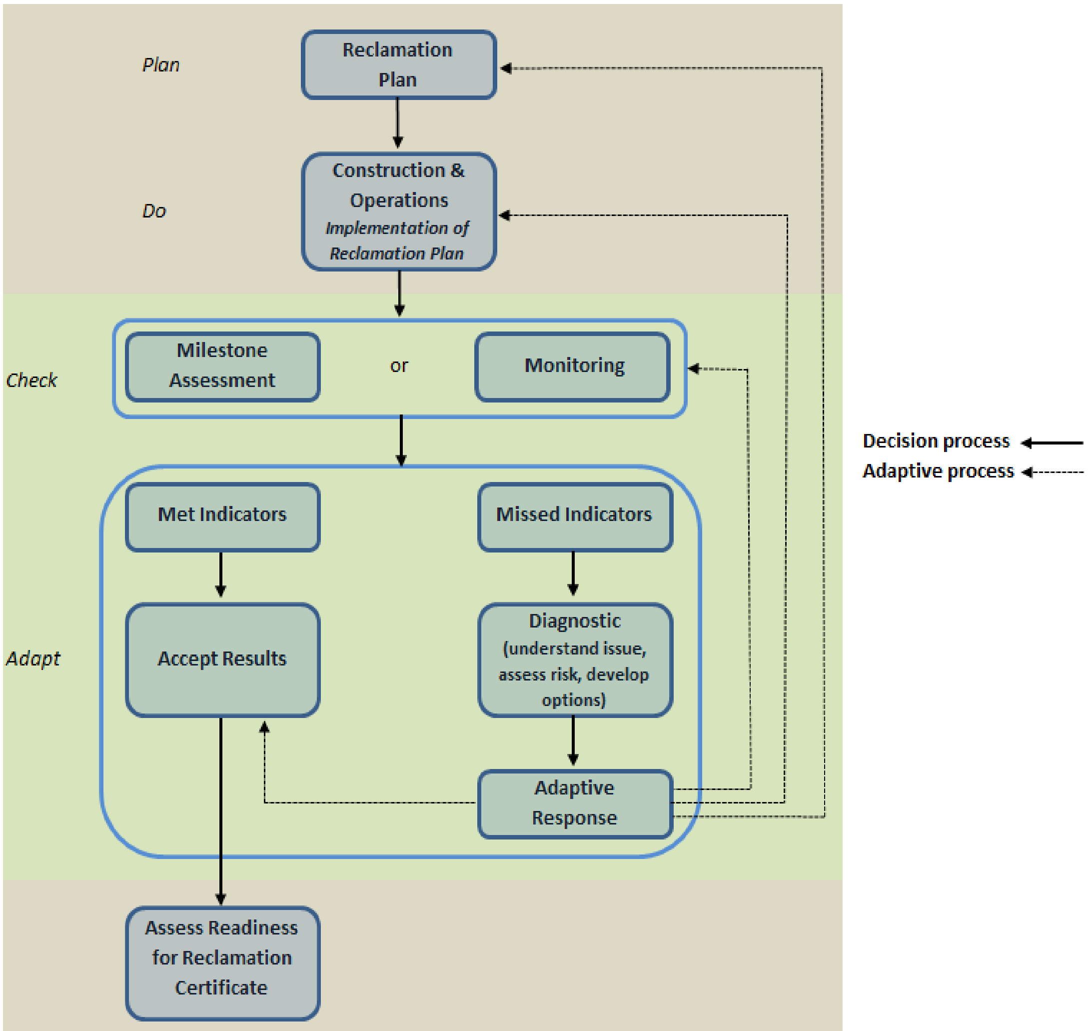

Figure 9: Example of adaptive management process to address any management or re-work that may be required if monitoring results are not meeting performance targets. Four possible adaptive paths are listed: 1) a change to the reclamation plan and thus the rest of the subsequent reclamation steps; 2) earthworks or revegetation works (construction); 3) further monitoring; and/or 4) accept results of not achieving performance target where further diagnostics have revealed low risk.

About the Reclamation Certificate Application

The final step in reclamation in an OSR development is obtaining a Reclamation Certificate. The reclamation certification application process for EPEA Approvals is beyond the scope of this document.

Borrow and aggregate pits used for facilities/operations regulated by an EPEA Approval are considered specified land. All specified land requires reclamation certification under the Conservation and Reclamation Regulation (Alberta Queen's Printer, 2016).

As operators are approaching the application time for reclamation certification, pre-application meetings with the appropriate regulator are recommended to discuss site-specific history, establish mutual expectations on the readiness of a reclaimed site for certification, clarify application requirements, and determine the status of other regulatory approval requirements (AER(c), 2016). Note that there is overlapping jurisdiction between AEP and AER for borrow pit reclamation. Thus, both agencies should be consulted.

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Appendix 1: Consolidated Reclamation Task List

Task List	Start Date	Completion Date	Completed By	Comments
Reclamation Milestone 1				
Initial Design				
Information gathering				
Insert structure (plant zones)				
Water body slope contours				
Water body shape				
Determine elevation of water table				
Water level control				
Design Assessment				
Materials balance				
Hydrology				
Geotechnical				
Final Design				
Develop final design drawings				
Soil Prescription Plan				
Determine plant zone area and final placement depths				
Revegetation Planning				
Plant species selection				
Determine plant collection and establishment methods				

Task List	Start Date	Completion Date	Completed By	Comments
Scheduling revegetation				
Site Preparation				
Water management				
Reclamation Construction Package				
Develop final reclamation drawings				
Develop construction package				
Reclamation Milestone 2				
Earthworks & Construction				
Communicate construction package and drawings to construction crew(s)				
Install mitigation controls				
Site grading & re-contouring				
Decompaction/roughing				
Soil Placement				
Topsoil and subsoil placement as per soil prescription plan				
Soil treatments and Amendments				
Reclamation Milestone 3				
Site Revegetation				
Acquire stocks/seeds				
Implement the revegetation plan				

Task List	Start Date	Completion Date	Completed By	Comments
Establishment Controls				
Manage for weeds				
Manage for wildlife				
Reclamation Milestone 4				
Develop Monitoring Plan				
Develop monitoring plan				
Develop indicators				
Monitoring and Focused Adaptive Management				
Monitor to determine establishment success				
Adaptive management to solve or address issues				

Appendix 2: Importance of Plant Zones for Habitat

Importance of plant zones for wildlife habitat (Galatowitsch & Van der Valk, 1998).

Animal Group	**Description**	**Example**	**Habitat Characteristic Guidelines to Attract each Animal Group**
Area Sensitive Birds	*Birds with large area requirements*	Trumpeter Swan, Sandhill Crane	At least 259 hectares of adjacent land in permanent cover; At least 40.4 hectares of semi-permanent to permanent water body. Riparian areas of 60m from water edge (Alberta Environment, 2010)
Open Water Birds	*Birds that require large, semi-permanent water bodies*	Horned Grebe, Western Grebe	Water body size greater than 16 hectares.
Marsh Generalists (birds)	*Birds that can use smaller water bodies and require some robust emergent vegetation*	American Coot, Red-winged Blackbird	Seasonal or semi-permanent marsh, or permanent water bodies. At least patches of shallow emergent and deep emergent vegetation.
Secretive Birds	*Birds of shallow marsh plant zones, including sedge meadows and wet prairie*	American Bittern, Wilson's Phalarope	Continuous vegetative cover of sedges and shallow emergent zones. Proportion of area <46 cm deep greater than 50%. Riparian areas of 60m from water edge (Alberta Environment, 2010).
Dabbling Ducks and Geese	*Birds which require several kinds of water bodies for life stage*	Mallard, Northern Pintail	Proportion of area <46cm deep greater than 50%. A buffer of permanent cover surrounding basin.
Shorebirds	*Birds that require extensive bare soils (for nesting and foraging)*	Killdeer, Sandpiper	Shallow or exposed unvegetated areas.
Reptiles and Amphibians		Canadian Toad, Northern Leopard Frog	Marsh, shallow open water wetlands. Riparian areas of 60m from water edge (Alberta Environment, 2010)

Animal Group	Description	Example	Habitat Characteristic Guidelines to Attract each Animal Group
Small Mammals		Shrews, Voles	Continuous vegetative cover containing sedges. A buffer of permanent cover surrounding basin.
Fur Bearers		Muskrat, Beaver	Well-developed vegetative cover of shallow and deep emergent zones.

Appendix 3: Recommended Establishment Techniques for Selected Aquatic Species

Note: These establishment properties for aquatic plant species are from CEMA (2014).

Checkmarks (√) indicate possible propagation/establishment methods. Asterisks (*) indicate a preferred or best propagation/establishment method.

Plant Zone	Common Name	Scientific Name	Recom-mended Planting Depth	Seeding Depth	Whole Plants	Roots/ Rhizo-mes	Seed	Cuttings
Floating Leaved Aquatics (Open Water Submergent Zone; 1.0-2.0m)	Duckweed	*Lemna spp.*	> 0cm		√*			
	Small yellow pond lily	*Nuphar lutea*	30-100cm	0-3 cm	√*	√*	√	
	Pygmy water lily	*Nymphaea tetragona*	< 2m	0-3 cm	√*	√*	√	
	Pondweed	*Potamogeton spp.*	< 2m		√*	√*	√	√*
	Water smartweed	*Polygonum amphibium*	0-50cm	48-0 cm	√*	√*	√*	√*
	Broad-fruit bur-reed	*Sparganium eurycarpum*	1-2.5m	2-3 cm		√*	√*	
	Water shield	*Brasenia schreberi*	0.5-3m		√	√	√	
Submerged Aquatics (Open Water Submergent Zone; 1.0-2.0m)	Pondweed	*Potamogeton spp.*	< 2m		√*	√*	√	√*
	Spiked water milfoil	*Myriophyllum sibiricum*	26-59cm		√	√	√	√
	Coontail	*Ceratophyllum demersum*			√*		√	√*
	Mare's tail	*Hippurus spp.*	18-200cm		√*	√*	√	√*
	Narrow-leaved water plantain	*Alisma gramineum*			√		√	
	Bladderwort	*Utricularia spp.*	0-100cm		√*			√*
Emergent (Marsh Plant Zone; 0.2-1.0m)	Giant bur-reed	*Sparganium eurycarpum*	15-45cm	2-3 cm	√*	√*	√	
	Common cattail	*Typha latifolia*						
	Sweet flag/Rat Root	*Acorus americanus*	15-50cm	0 cm	√*	√*	√	
	Hardstem bulrush	*Schoenoplectus acutus*	< 1.5m	0 cm	√*	√*	√*	
	Softstem bulrush	*Schoenoplectus tabernaemontani*	< 120cm	0-1 cm	√*	√*	√*	
	Rush	*Juncus spp.*	< 20cm	0 cm	√*	√*	√	

Plant Zone	Common Name	Scientific Name	Recom-mended Planting Depth	Seeding Depth	Whole Plants	Roots/ Rhizo-mes	Seed	Cuttings
	Arum-leaved arrowhead	*Sagittaria cuneata*	0-30cm	0 cm	√*	√*	√	
	Water arum	*Calla palustris*	0-20cm	3 cm	√*	√*	√*	√*
	Buckbean	*Menyanthes trifoliata*	0-30cm			√*	√	
	Marsh-five-finger	*Comarum palustre*	-53-3cm				√	√*
	Spike rush	*Eleocharis spp.*	-3-60cm	0 cm	√*	√*	√	
	Northern water plantain	*Alisma triviale*	0-15cm	0 cm	√*	√*	√*	
	Sedge	*Carex spp.*	-50-50cm	0-5 cm	√*	√*	√	
	Yellow marsh-marigold	*Caltha palustris*		0 cm	√	√	√	
	Hemlock water parsnip	*Sium suave*	-50-15cm				√	
	Water horsetail	*Equisetum fluviatile*	-50-70cm		√*	√*		√
	Reed grass	*Calamagrostis canadensis*	-50-15cm	< 1 cm	√*	√*	√	
	Slough grass	*Beckmannia syzigachne*	< 15cm	< 1 cm			√*	
	Wool-grass	*Scirpus atrocinctus*	< 30cm	3 cm	√*	√*	√	
	Small-fruited bulrush	*Scirpus microcarpus*		3 cm	√*	√*	√	
Wet Meadow (Marsh Plant Zone; 0.1-0.2m)	Reed grass	*Calamagrostis canadensis*	-50-15cm	< 1 cm	√*	√*	√	
	Sedge	*Carex spp.*	-50-50cm	0-5 cm	√*	√*	√	
	Slough grass	*Beckmannia syzigachne*	< 15cm	< 1 cm			√*	
	Tufted hairgrass	*Deschampsia cespitosa*	< 0cm	< 0 cm			√*	
	Manna grass	*Glyceria grandis*		< 1 cm	√		√*	